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JOINT INSTITUTE FOR NUCLEAR RESEARCH

η-nuclei in the SCAN experiment

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η-meson nucleus

- η-meson nucleus – bound state of η-meson and nucleus
- Short lifetime $\tau_\eta = 5{,}5.10^{-19}$ s, study of η-nucleon interaction (ηN) is based on study of scattering amplitude ηN for processes:

  $\pi + N \rightarrow \eta + N$

  $\gamma + N \rightarrow \eta + N$

  $N + N \rightarrow \eta + N + N$
- ηN interaction near threshold is mainly determined by the S11(1535) resonance, which is just 49 MeV above the ηN threshold and has a width $\Gamma \approx 150$ MeV
- Mass of S11(1535) resonance is very close to threshold of ηN production ($\eta N_{treshold} = m_\eta + m_N \approx 1486$ MeV)
- S11(1535) is unstable:

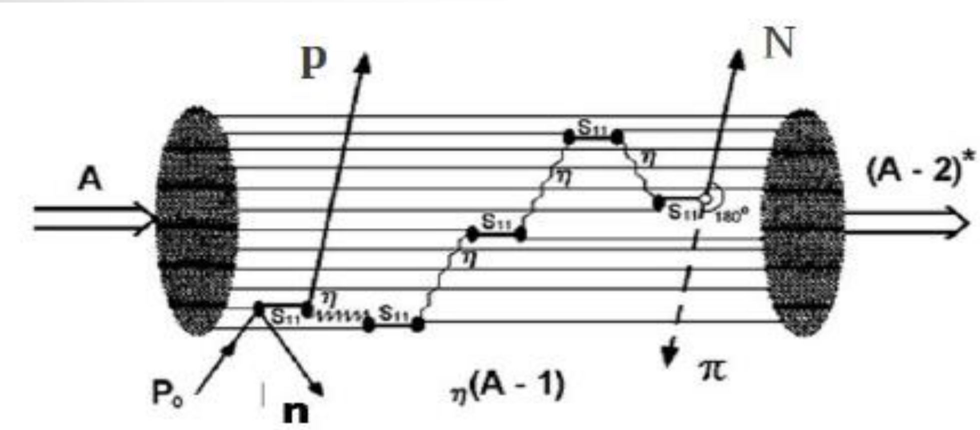
  $S11(1535) \rightarrow \pi + N$

  $S11(1535) \rightarrow \eta + N$

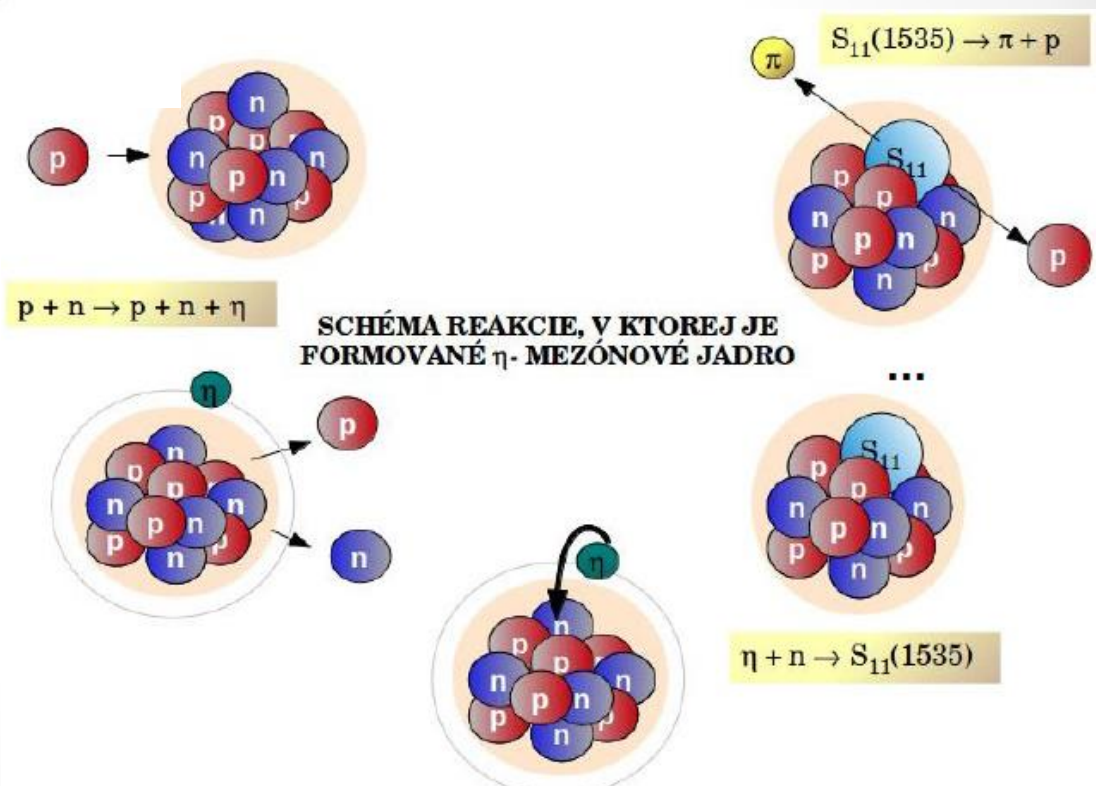
  $S11(1535) \rightarrow \pi + \pi + N$

Mechanism of η-nucleus formation

- $\eta + N \rightarrow S11(1535) \rightarrow \eta + N \rightarrow S11(1535) \rightarrow \ldots \rightarrow S11(1535) \rightarrow \ldots \rightarrow \pi + N$

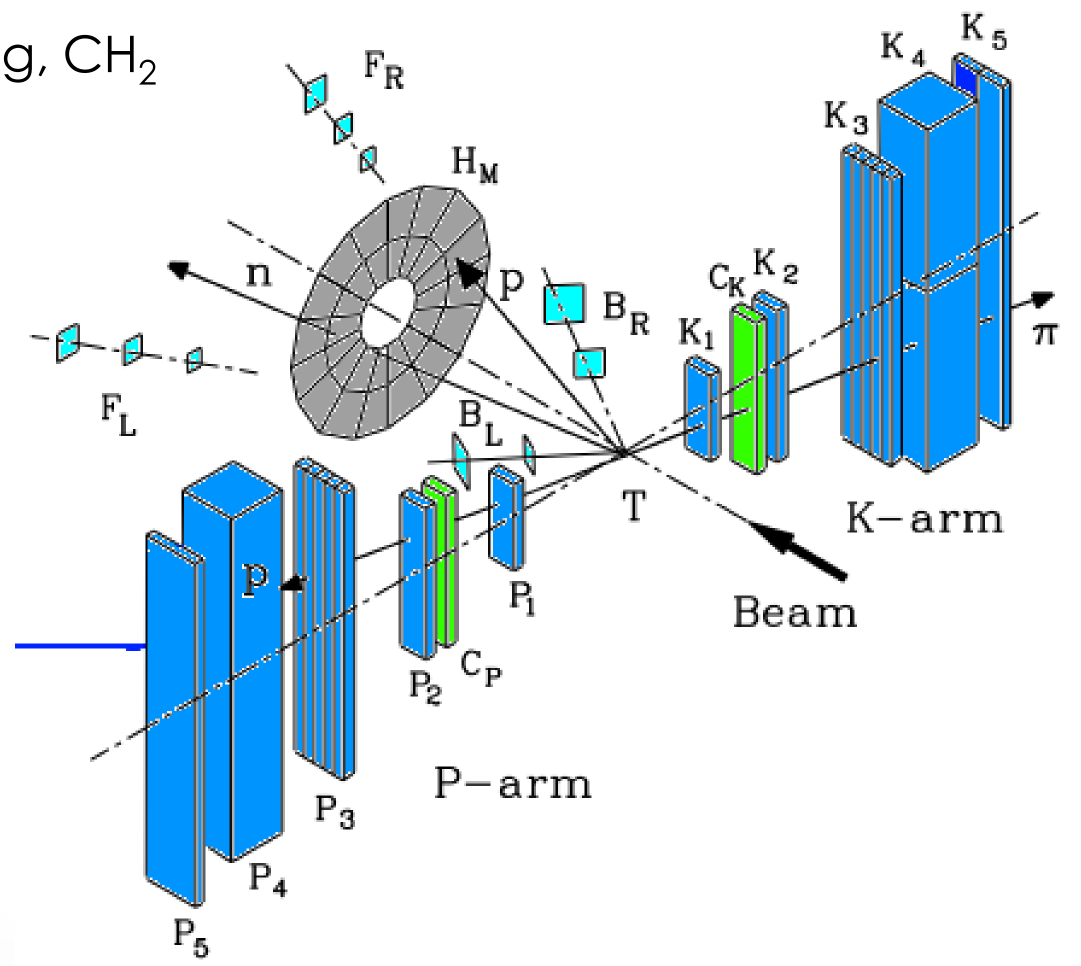


- $p_0 + A \rightarrow N_1 + N_2 + {}_{\eta}(A\text{-}1)$
  ${}_{\eta}(A\text{-}1) \rightarrow \pi + N_3 + (A\text{-}2)$



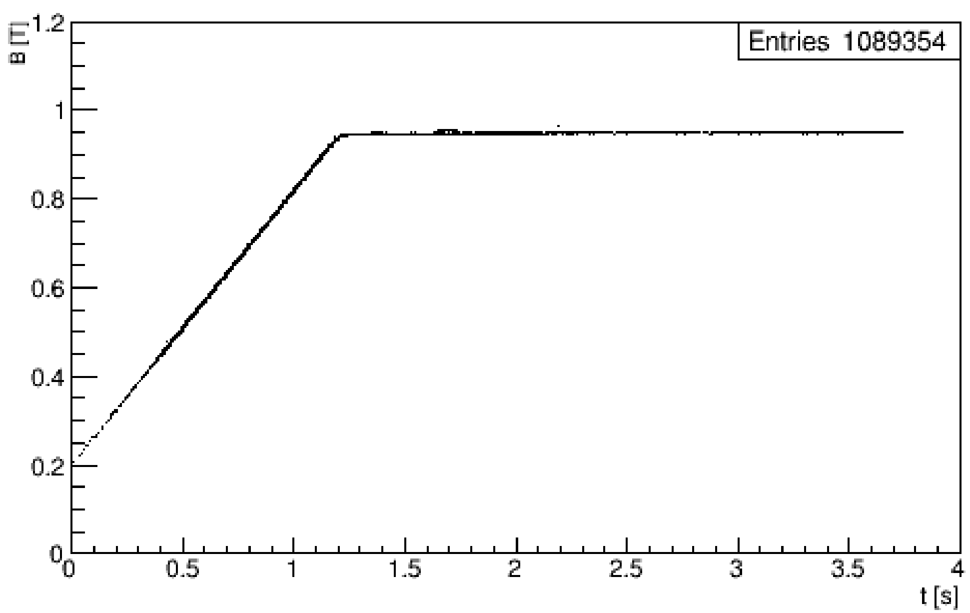
SCAN 2

- Two-arm spectrometer
- experiment on internal target of Nuclotron
- Initial particles: deuterons
- target: ^{12}C, ^{27}Al, ^{64}Cu, ^{183}W, ^{108}Ag, CH_2



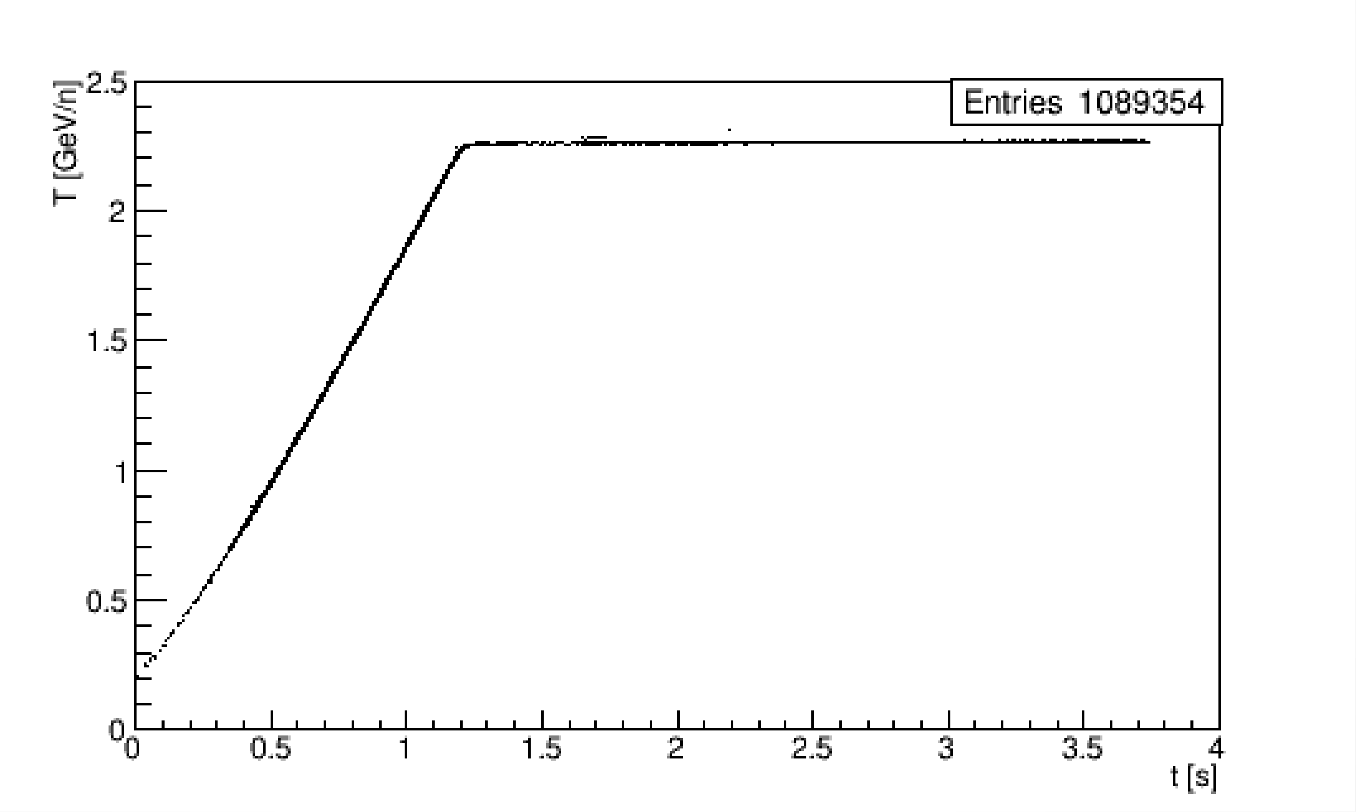
Experimental data

Initial particles: deuterons
Target: Carbon
39. run – not constant magnetic field
The main task of processing these data is to calculate the minimum energy needed to create eta-nuclei.



Dependence of kinetic energy of initial deuterons on magnetic field:

$$T = \sqrt{{m_d}^2 + (0.3BZR)^2} - m_d$$



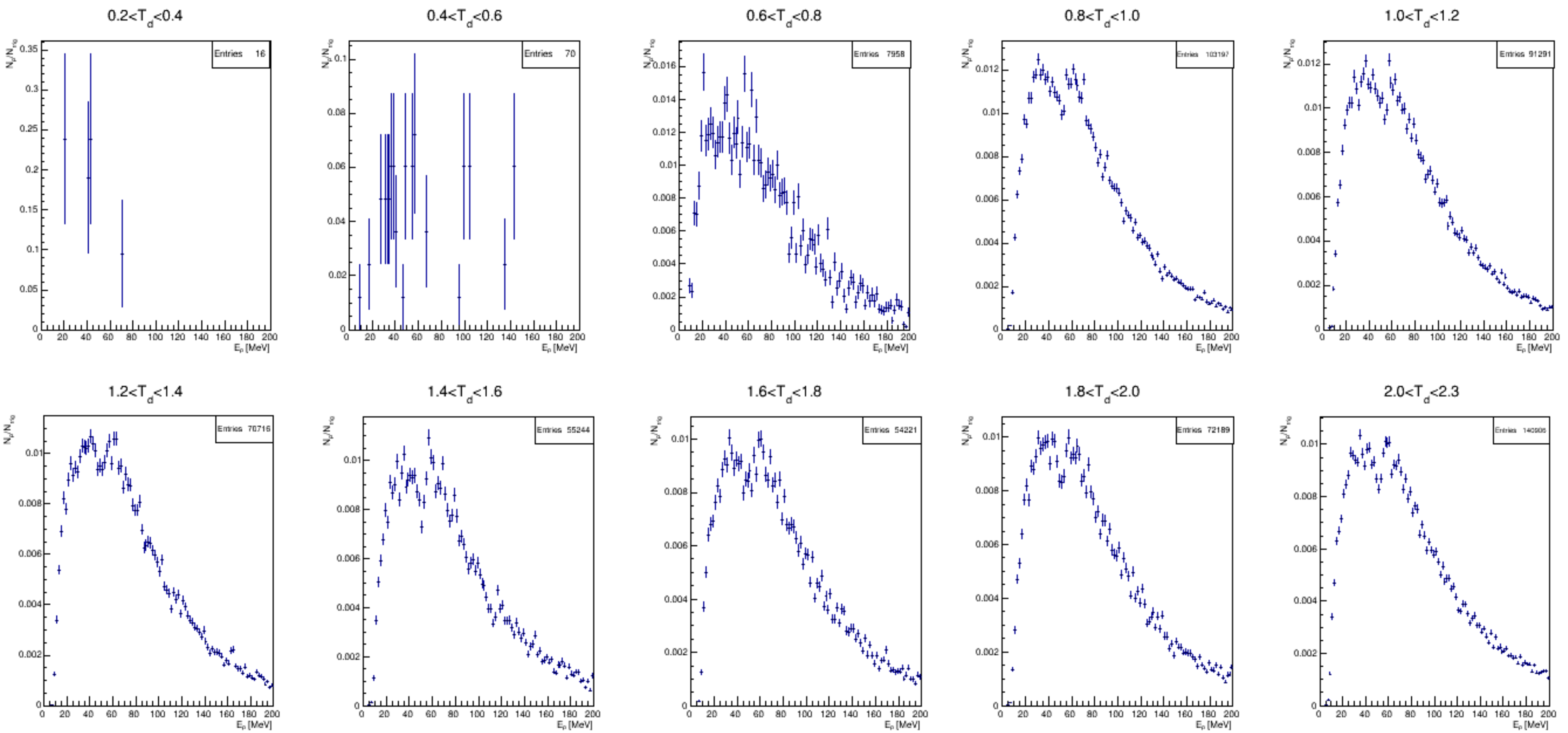
Maximum T_d = 2.3 GeV/nukl

Determination of minimum energy to create η-nuclei – detection πp pair:

- energy spectrum of protons for different kinetic energy intervals of deutrons.
- if protons are from η-nuclei decay – observed resonance - the second peak should be seen in value 90 MeV

$$minimal\ T_d = 0.8\ GeV/nukl$$

- -> need to increase statistics and make corrections

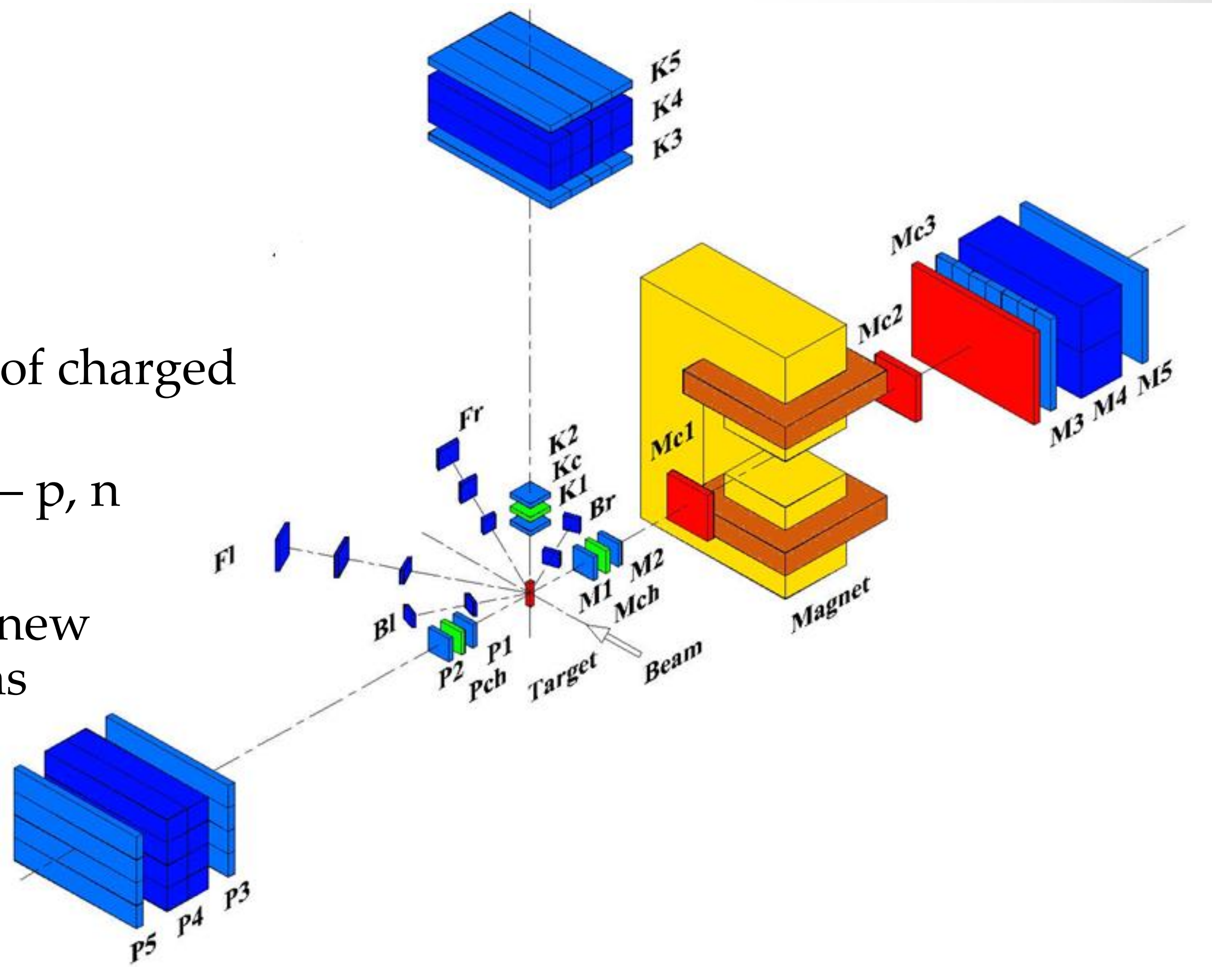


SCAN 3

- SCAN2 problems : charge identification of pions
- background at 170°
- only pπ channel

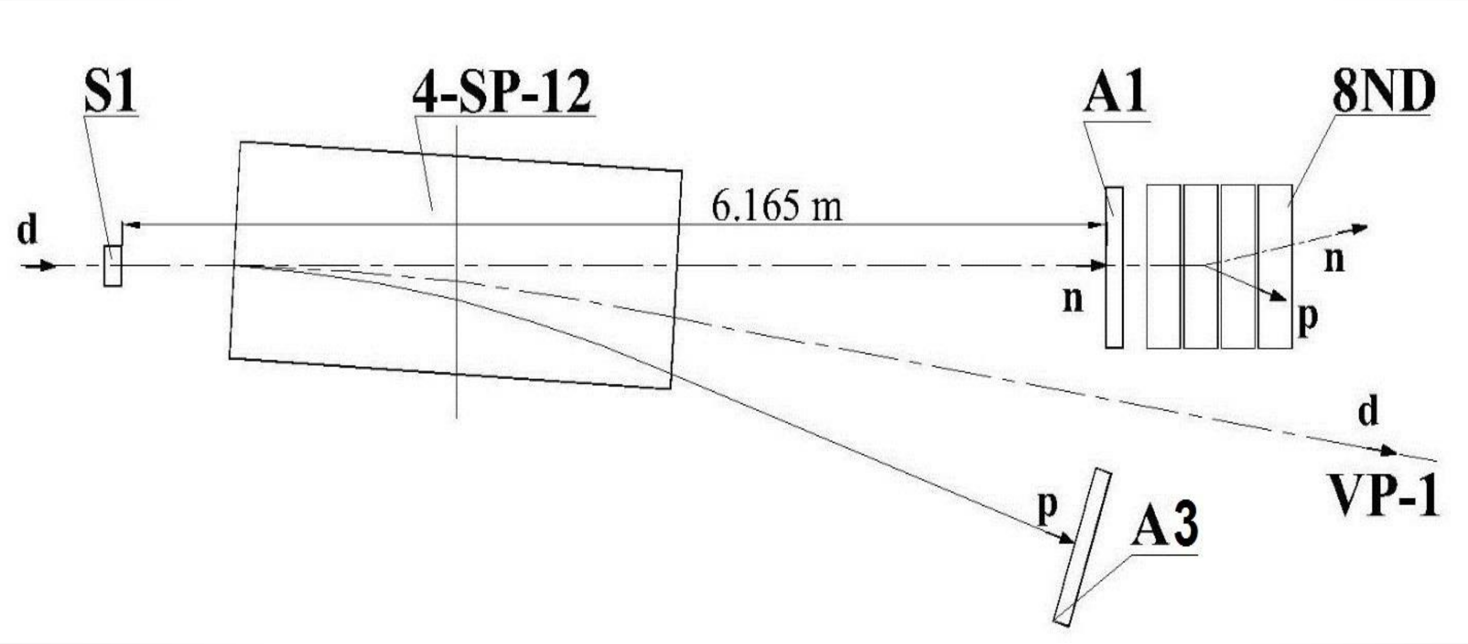
SCAN3

- Three-arm spectrometer
- Analyzing magnet – identif. of charged particles
- P/K arm TOF spectrometers – p, n
- Background at 90°
- Neutron detector – study of new decay channels with neutrons



Neutron detector

Deuteron beam: $E_d = 3GeV/nukl$ using Nuclotron

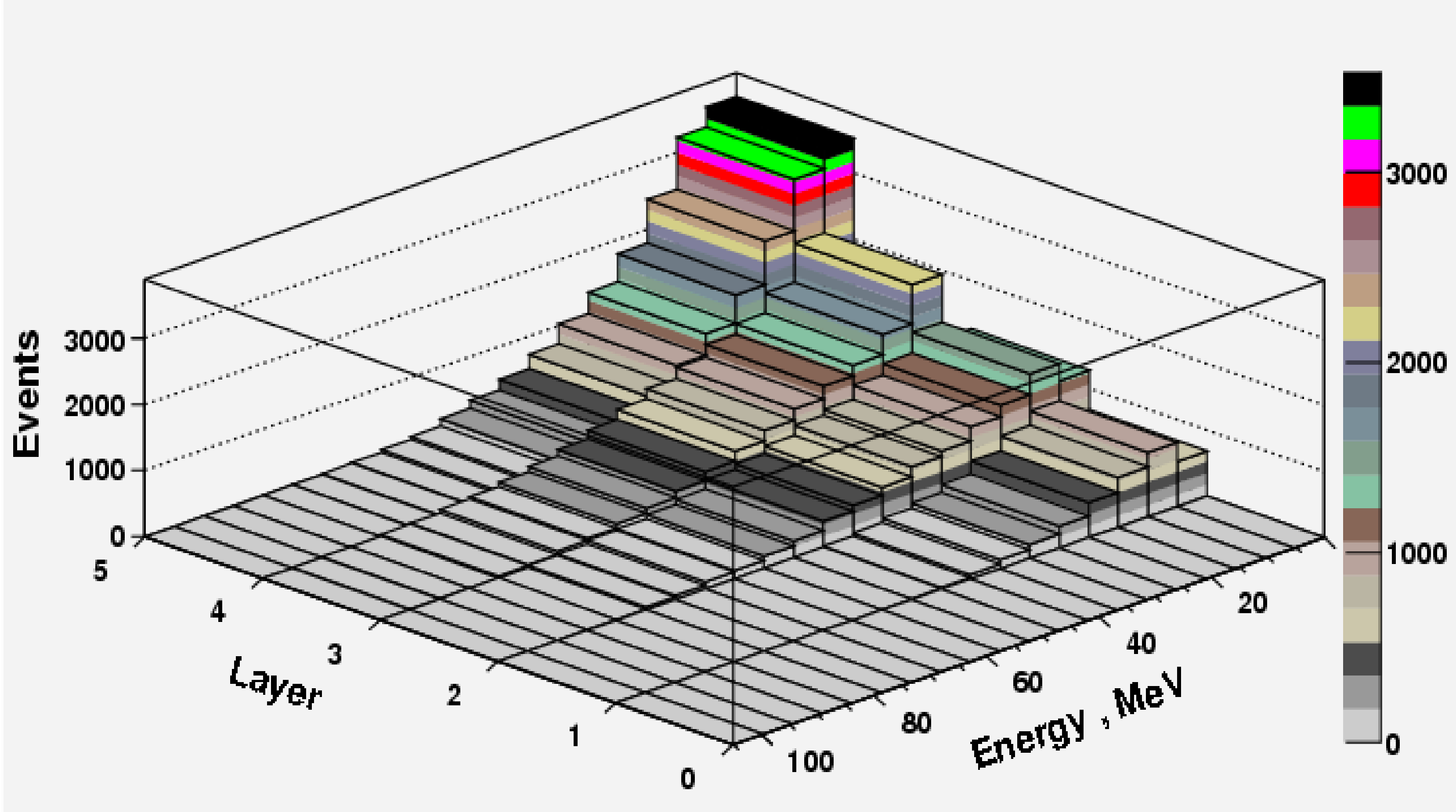


To test the neutron detector, a deuteron stripping reaction on fixed target to obtain neutron beam was used.

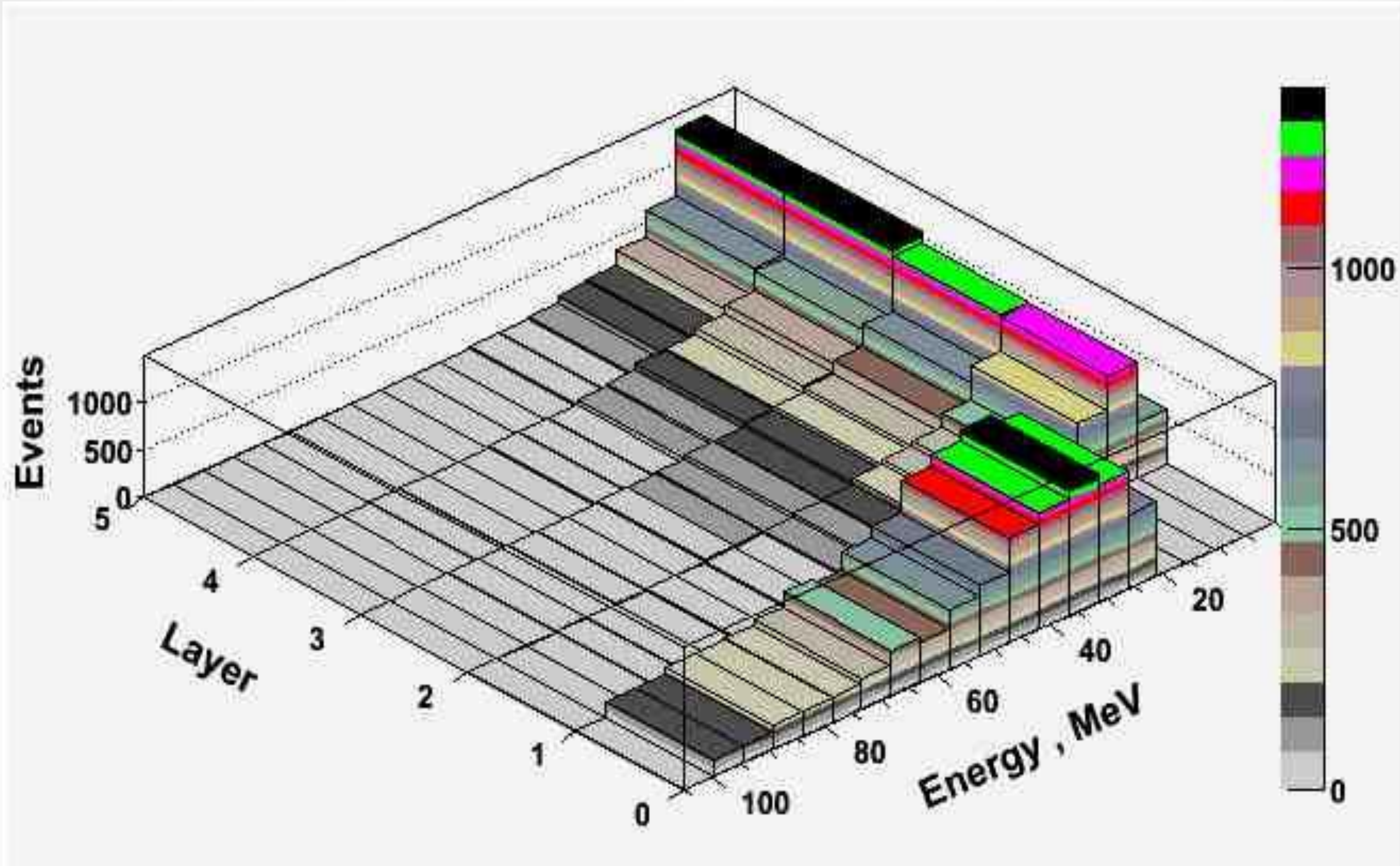
Idea of experiment:

Method „time-of-flight“ (TOF):

- Neutrons flying through the detector layers at some point collides with the proton of the material and then knock out it from this material.
- If the charged particle starts moving in the scintillator, the counter is running.
- Depending on the length of the flight and the arrival time of the signal from the interaction point to the counter, it is possible to estimate the velocity and energy of the neutron.



- Distribution of energy losses of neutrons in each layer and number of signal depending on the layer.
- The most of neutrons interact in the 4. layer of the detector and the number of events decreases with increasing neutron energy.

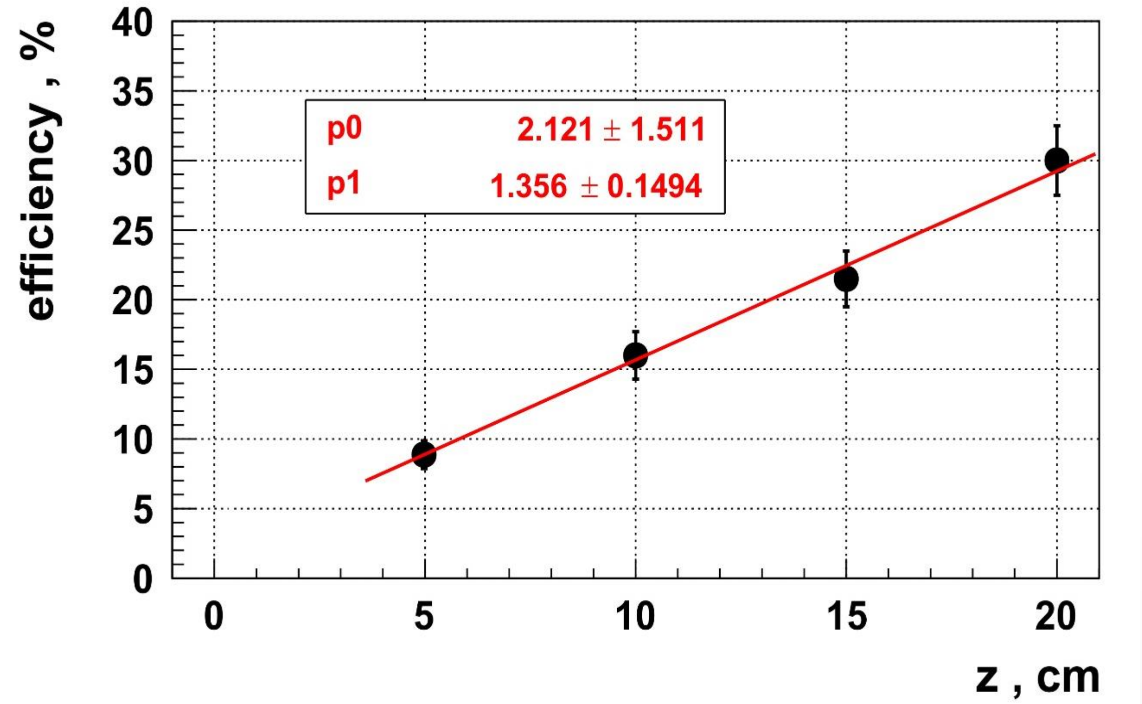


- If charged particles fly in range of detector, almost all of the energy is released in the first layer.

Time resolution for two closest layers

N_i-N_k	N_1-N_3	N_3-N_5	N_5-N_7	N_2-N_4	N_4-N_6	N_6-N_8
σ [ns]	0.27	0.27	0.3	0.44	0.3	0.2

Efficiency of neutron detector: 27 % for 4 scintillation layers



End of September:
Test of new Neutron detector with 5 layers of scintillator, which are ready now. For test will be used cosmic rays.

Conclusions

- The dependence of kinetic energy on magnetic field was calculated - maximum energy of deuteron beam is 2.3 GeV/nucl.
- Determination of the minimum energy for η-nuclei formation: 0.8 GeV/nucl.
- The first prototype of the neutron detector was investigated.
- Detection efficiency of neutrons using four layers is 27%.
- This detector can be used for its time resolution in the experimental setup SCAN3 for recording neutrons in πn and pn decay channels of the η-nucleus.

Thank you for attention

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